

Biomass Quality and Combustion: Not All Biomass is Equal



WISCONSIN
BIOENERGY
INITIATIVE

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Agenda

- Quantity
 - How much is available?
 - Where is it at?
- Quality
 - Survey on sample properties
 - Impact on conversion limitations
- Impact to current business



Wisconsin Biomass Numbers

Woody resources

Biomass Type / Estimate methodology	Million Dry Tons/ year
Roundwood	
Acres of Forestland – 0.5 ton/yr/acre (d.b.)	8.14
TPO Roundwood	6.21
Wood Residuals	
TPO Harvest residuals	1.52
TPO Roundwood – 15%	1.29
BTS Woody residuals@\$40/ton (d.b.)	1.05
Energy Crops	
BTS Woody@\$60/ton (d.b.)	2.29



Wisconsin Biomass Numbers

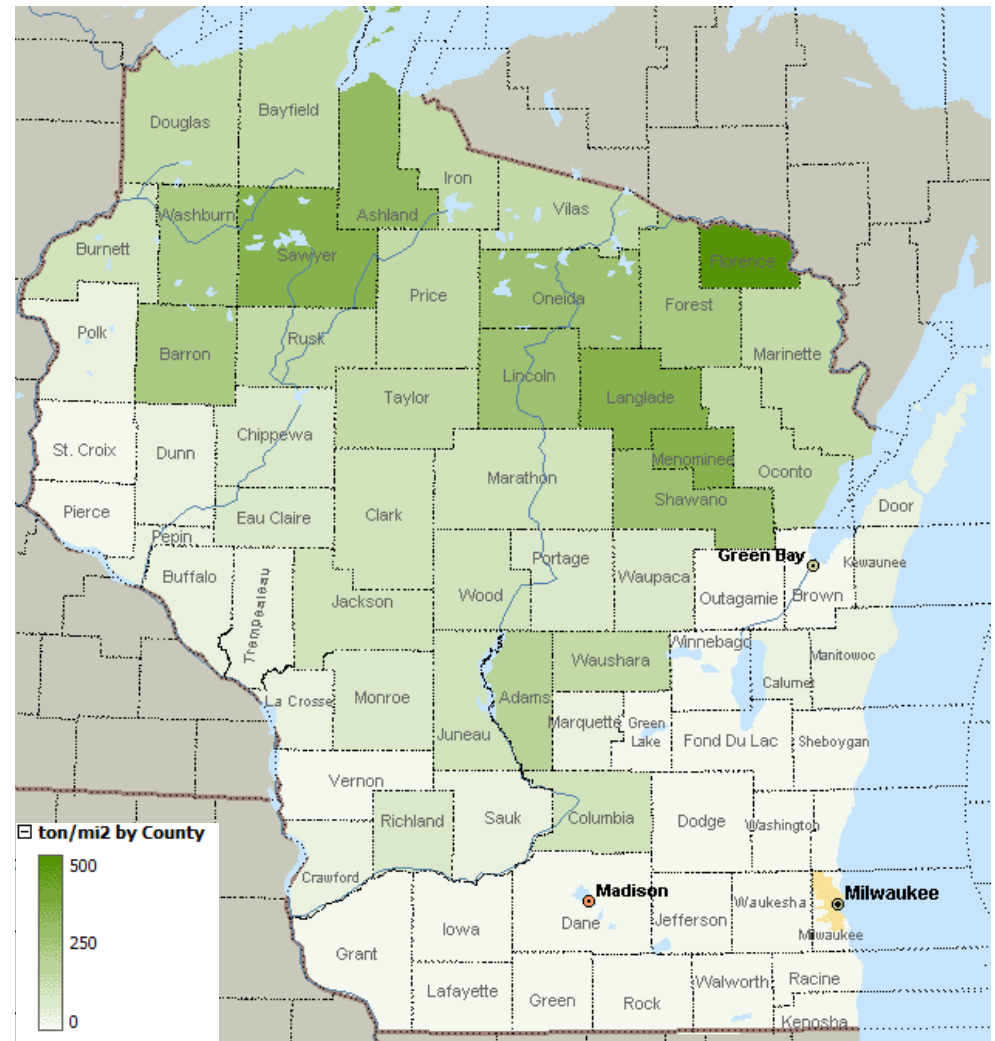
Herbaceous resources

Biomass Type / Estimate methodology	Million Dry Tons/ year
Corn Stover Estimates	
NASS Data	2.81
BTS Data@\$60/ton (d.b.)	2.49
Energy Crops	
BTS Grasses@\$80/ton (d.b.)	0.15
WBA Fallow Hay/CRP	3.13
Manure	
NASS Dairy	4.77



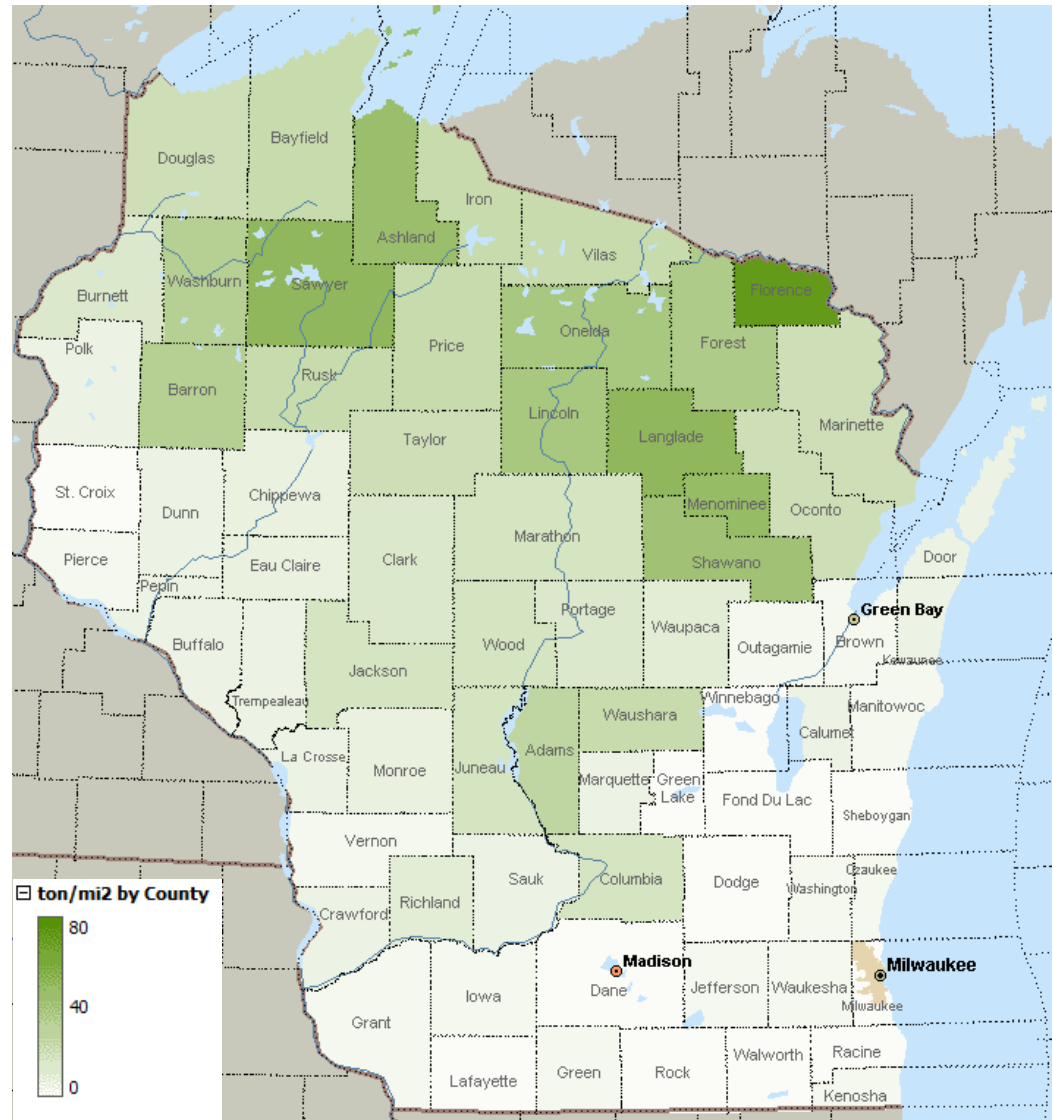
Roundwood Harvested

- Using TPO roundwood data
- Existing market for materials



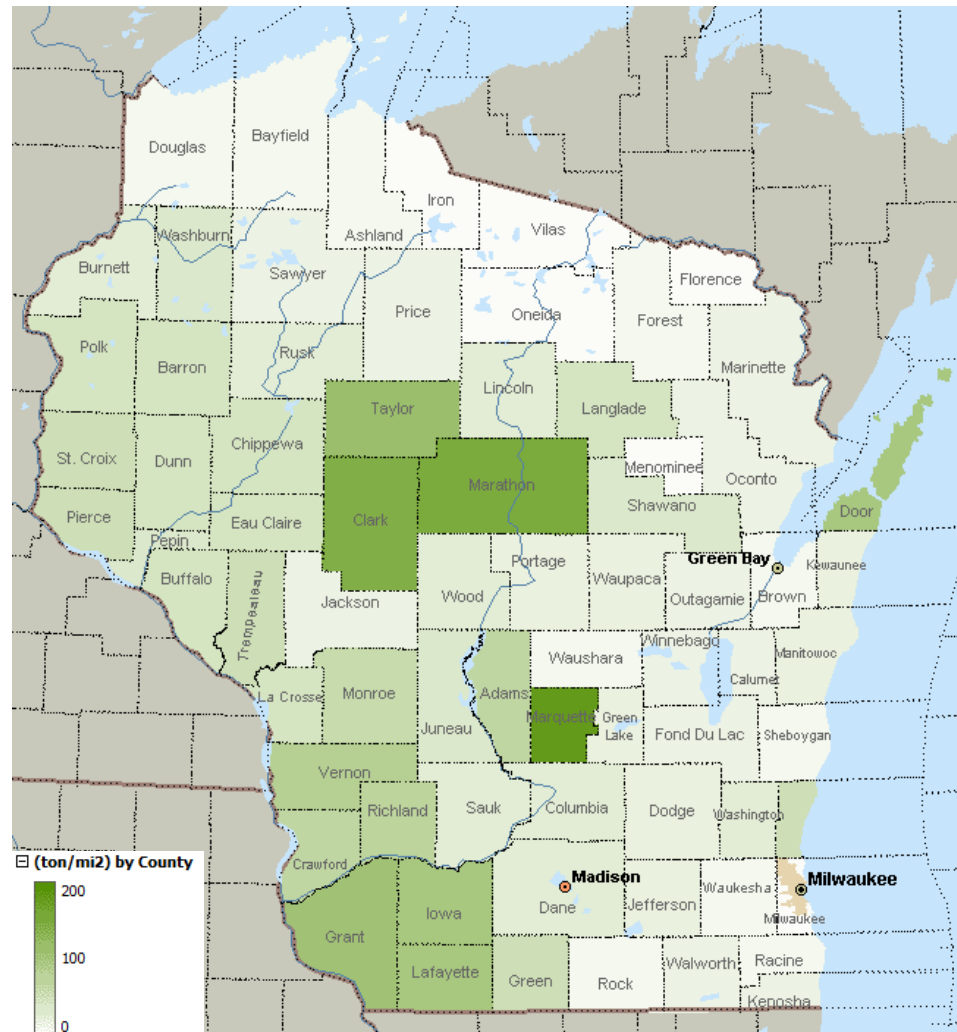
Wood Residuals

- Using TPO forest residual data
- Does not consider economics



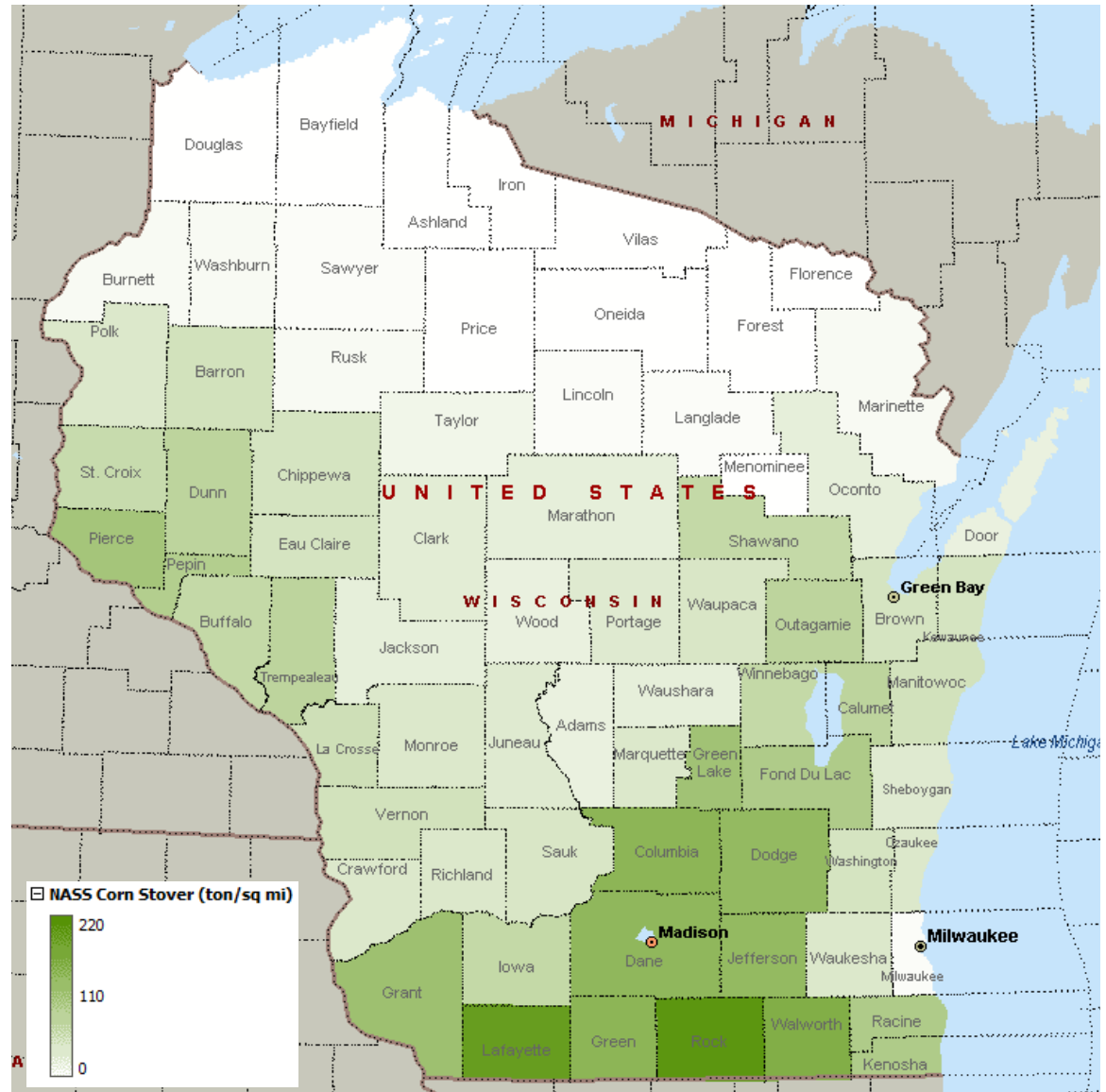
Wood Energy Crop

- Using BTS data
- Future Project
Average of Baseline case at \$60/ton



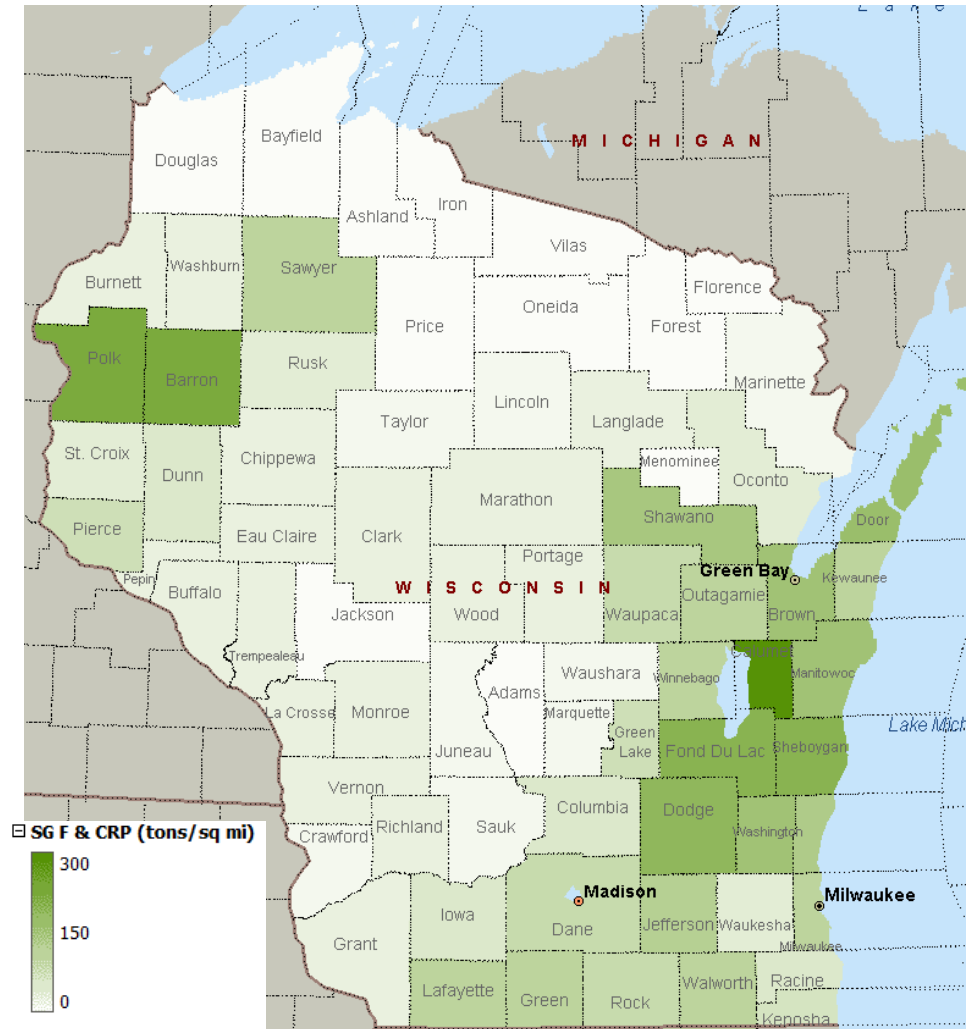
Corn Stover Distribution

- Using NASS data
- Assumes stover:grain at 1:1 and 25% removal



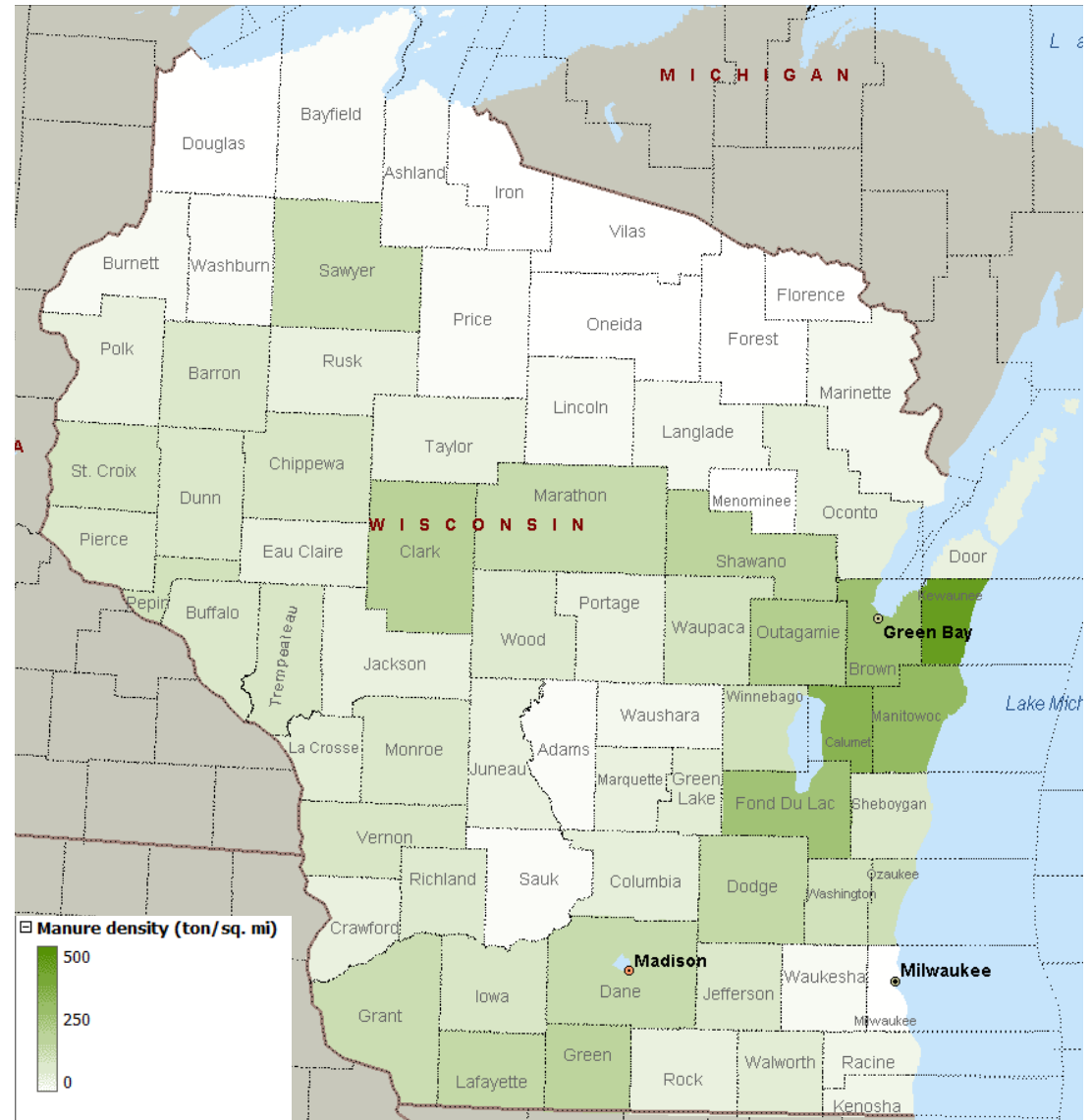
Switchgrass Fallow/CRP land

- Wisconsin Bioenergy Atlas
- Assume 2.5 tons/year yield



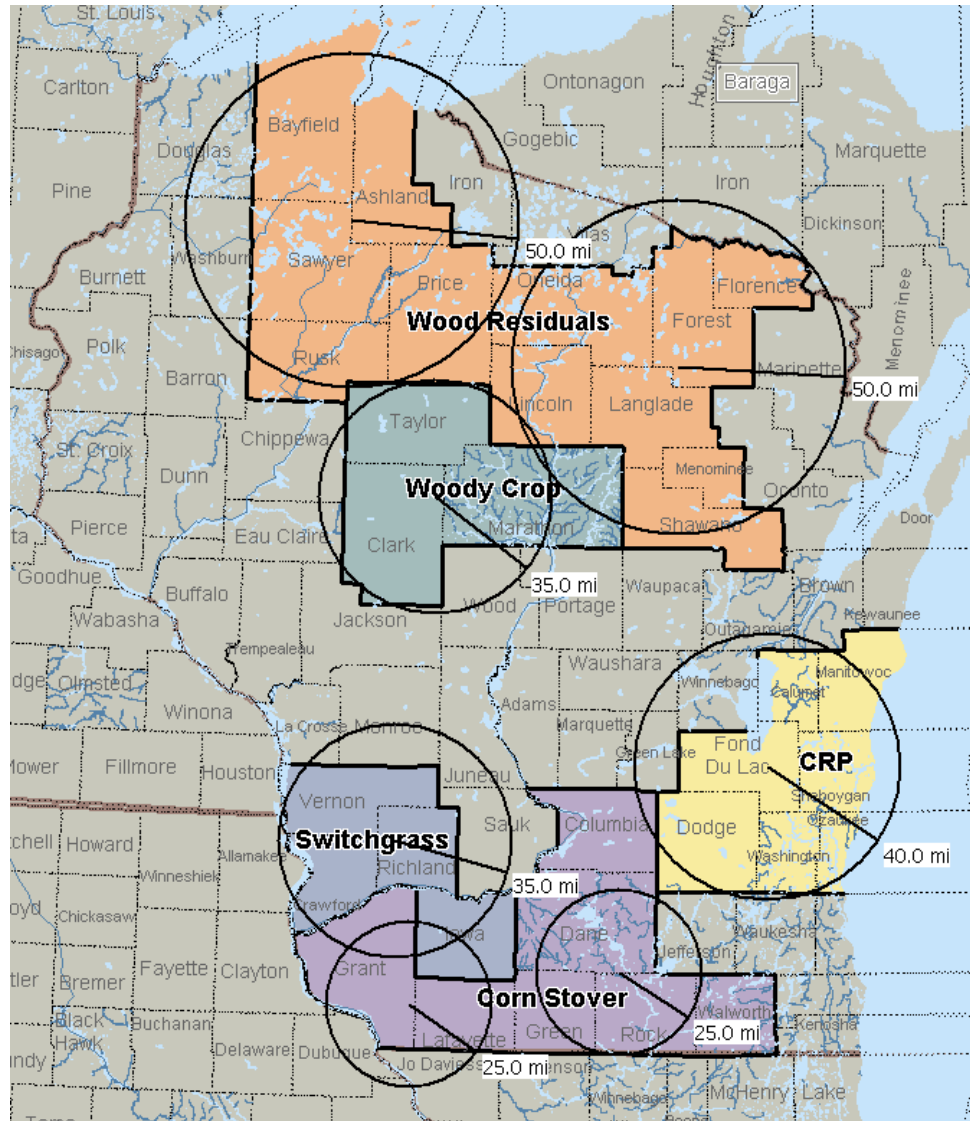
Manure Distribution

- Using NASS data for dairy cows



Biomass Opportunities

- Identified top counties with biomass densities
- Looked for natural groupings
- Used circles to identify processing sites
>200,000 tons/year



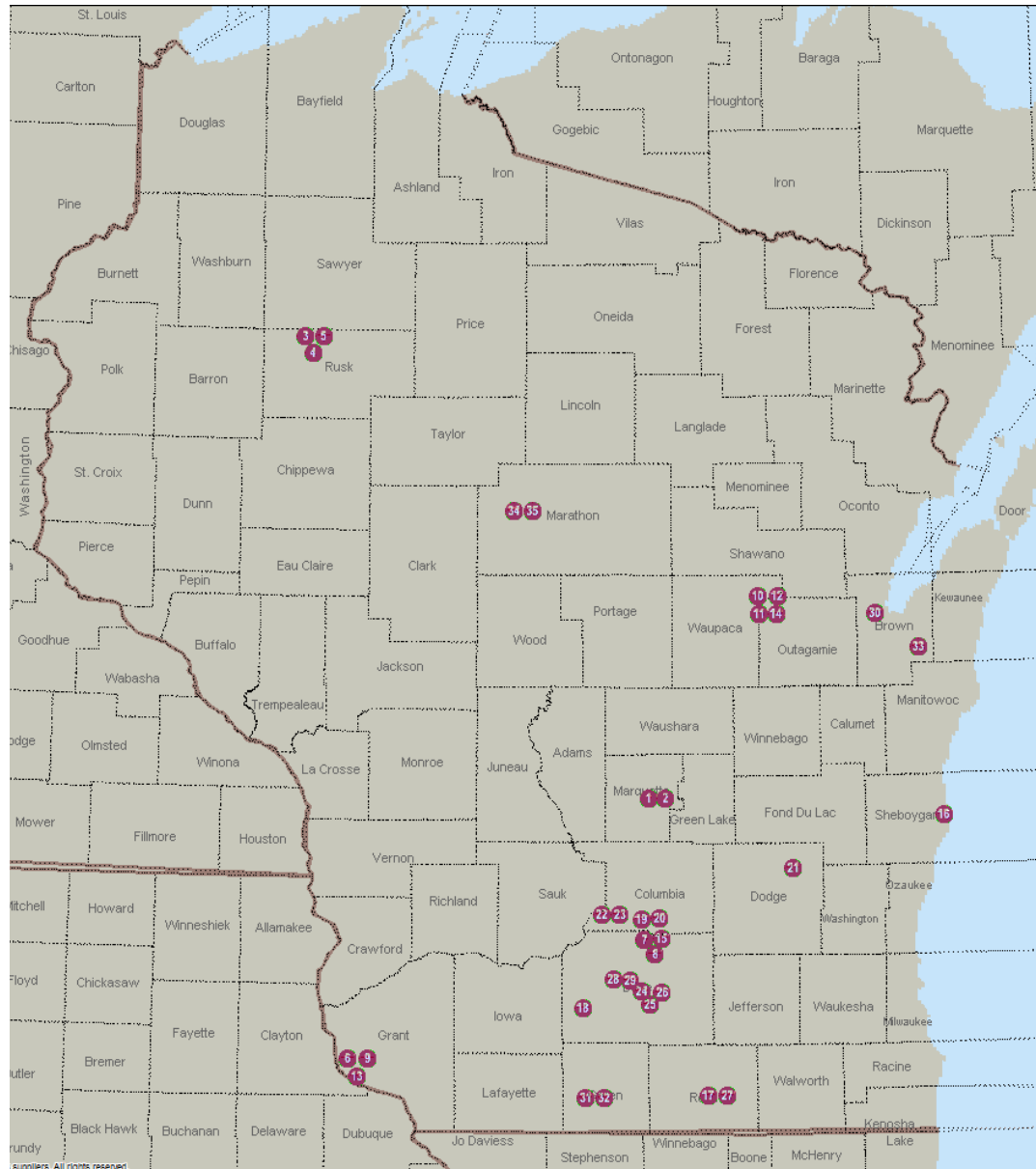
Quality - Biomass Analyses

- Proximate Analysis
 - Moistures, Volatile Matter, Fixed Carbon, Ash
- Heating Value
- Ultimate Analysis
 - C, H, N, O, S
- Cl, Hg, Mineral Ash Analysis
- Crude Protein
- Carbohydrate



Lignin

Biomass Samples



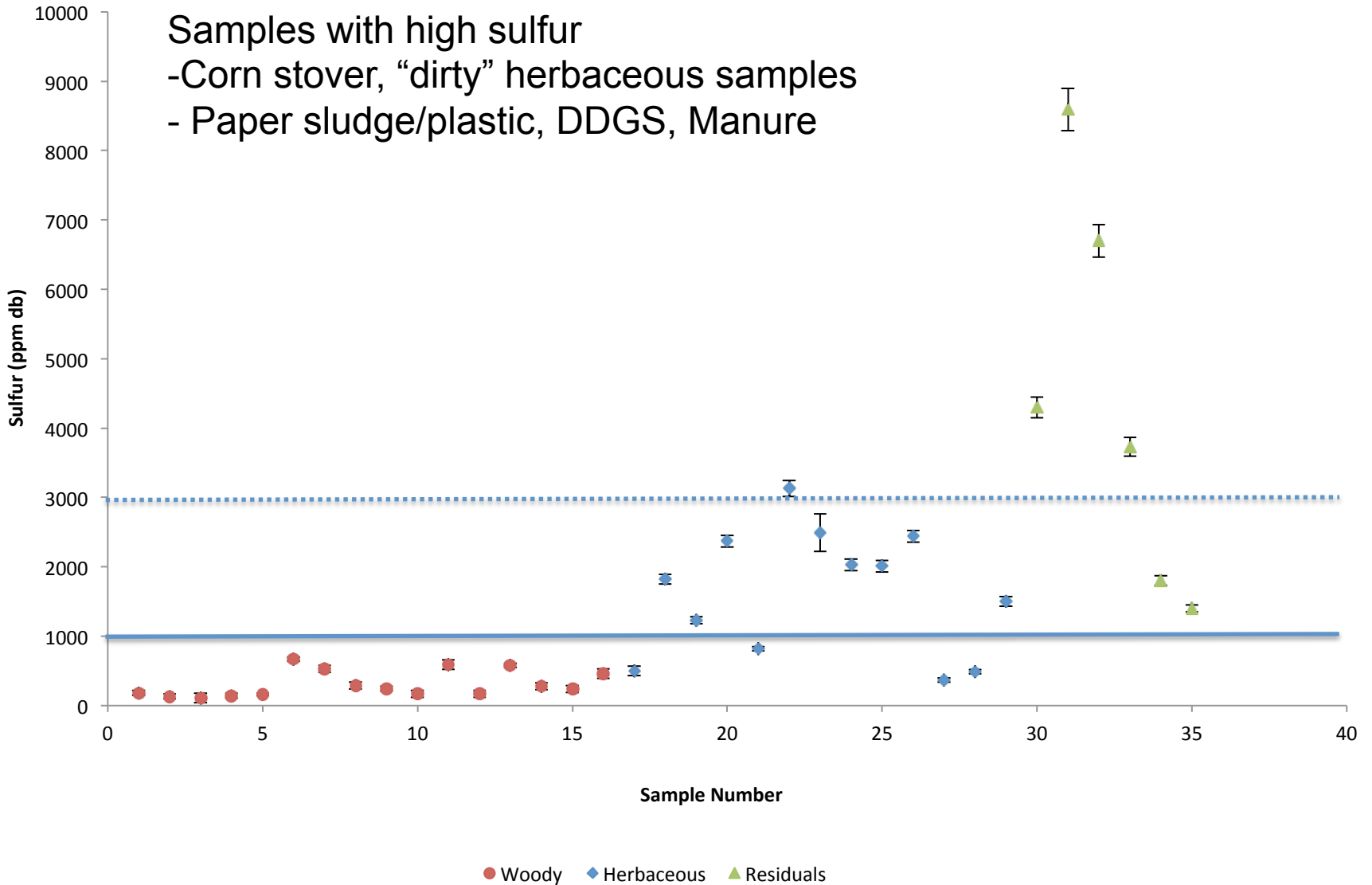
Sample Number	Category	Description
1	Woody	Industrial Pellet - 80% Hardwood (debarked), 20% recycled ag. plastic
2	Woody	Industrial Pellet 90% Hardwood (debarked), 10% recycled ag. Plastic
3	Woody	Premium Wood Pellet Fuel
4	Woody	Premium Wood Pellet Fuel
5	Woody	Premium Wood Pellet Fuel
6	Woody	Wood chips - Mixed softwoods
7	Woody	Wood chips - Mixed hardwoods
8	Woody	Hardwood hog fuel - primarily bark waste
9	Woody	Wood chips - Mixed hardwoods
10	Woody	Wood - Locust (whole tree)
11	Woody	Wood - Pine (whole tree - high amount of needles)
12	Woody	Wood - Maple (whole tree)
13	Woody	Mixed hardwood (whole tree)
14	Woody	Mixed softwood (red & white pine)
15	Woody	Municipal Tree Trimmings
16	Woody	Woody Biomass, Whole tree
17	Herbaceous	Switchgrass Pellets
18	Herbaceous	Switchgrass Pellets
19	Herbaceous	Switchgrass
20	Herbaceous	Switchgrass
21	Herbaceous	Briquetted corn stover
22	Herbaceous	Corn stover
23	Herbaceous	Corn stover
24	Herbaceous	Ditch grass bale 1
25	Herbaceous	Ditch grass bale 2
26	Herbaceous	Ditch grass bale 3
27	Herbaceous	Big Bluestem Pellets
28	Herbaceous	Miscanthus stalks
29	Herbaceous	Miscanthus stalks
30	Other	Industrial pellet made from paper mill sludge, waste paper, film waste
31	Other	Distiller's Grains - Ethanol Plant A
32	Other	Distiller's Grains - Ethanol Plant B
33	Other	Manure briquette - Dried & densified manure, bedding, and sawdust
34	Other	Manure briquette - Dried & densified manure, bedding, and sawdust
35	Other	Manure & sawdust bedding

Identified Thermal Conversion Issues

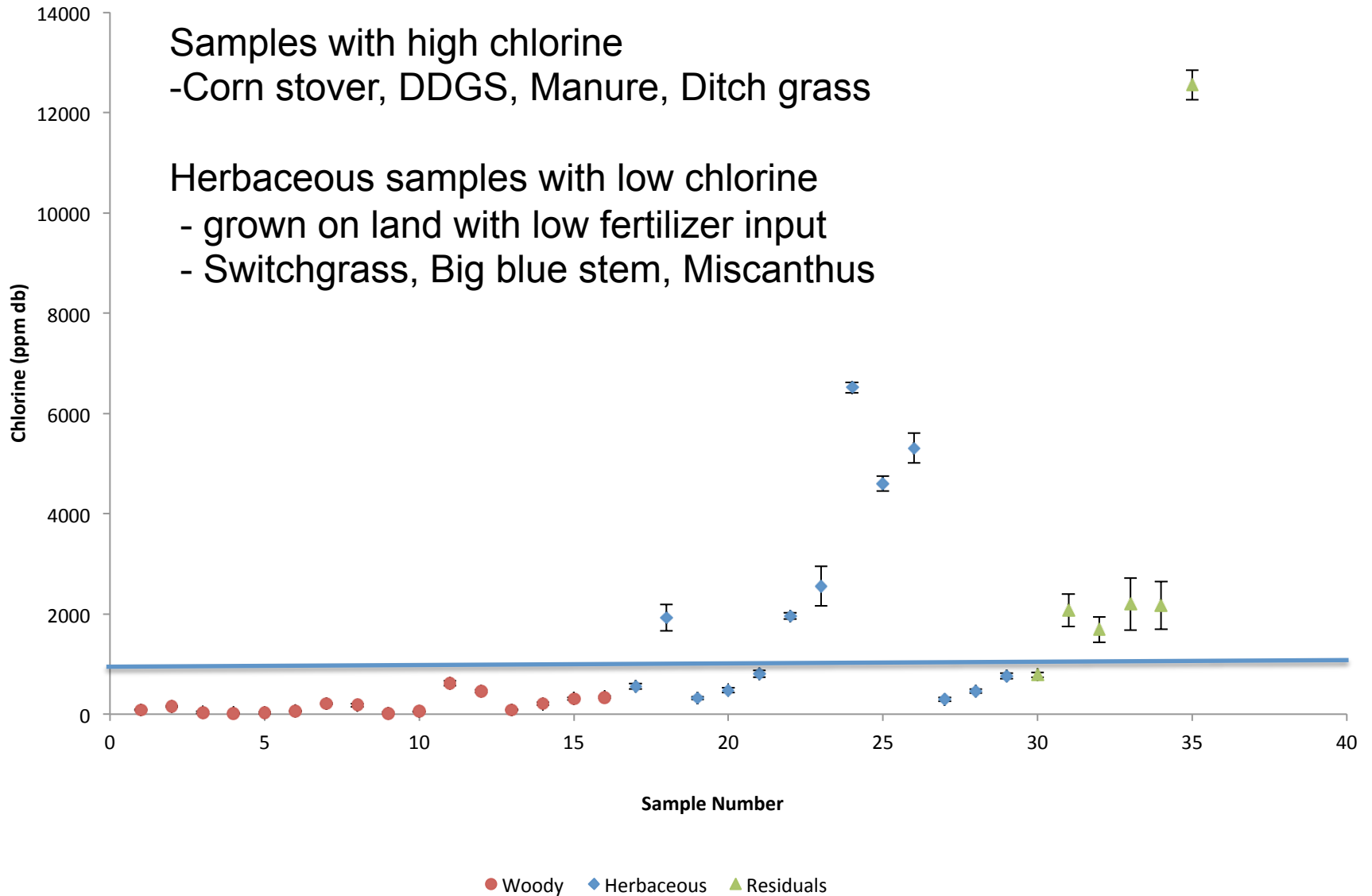
Fuel Characteristic	unit	Woody	Herbaceous	Other ^a
Moisture	(% wt wb)	2.74% - 49.94%	2.45% - 18.32%	6.96% - 28.62%
LHV	Btu/lb	3200 - 8946	5926 - 6923	5019 - 8145
Ash	<10 (% wt db)	0.63% - 9.33%	2.66% - 10.83%	5.21% - 19.38%
N	<25000 ppm db	200 - 10200	3700 - 15500	2500 - 42700
S	<1000 ppm db	110 - 670	370 - 3130	1400 - 8590
Cl	<1000 ppm db	19 - 617	293 - 6516	786 - 12550
Hg	<0.02 ppm db	<0.001 - 0.024	<0.001 - 0.017	<0.001 - 0.027
Fouling Index	<0.8 lb alkali/MMBtu	0.099 - 1.471	0.227 - 1.919	0.314 - 1.482

^aOther includes DDG, manure, and plastic/sludge samples

Sulfur



Chlorine



Quality Summary

- Link known technologies with Biomass based on quantity
- Thermochemical → Woody & Woody Residuals
 - Combustion
 - Gasification
- Biological → Herbaceous & Herbaceous Residuals
 - Fermentation
 - Anaerobic digestion



Impact to Existing Industry

- Most developed biomass industry is forest products
- Wisconsin has a large pulp & paper industry
- What would the impact of increased woody biomass demand be?

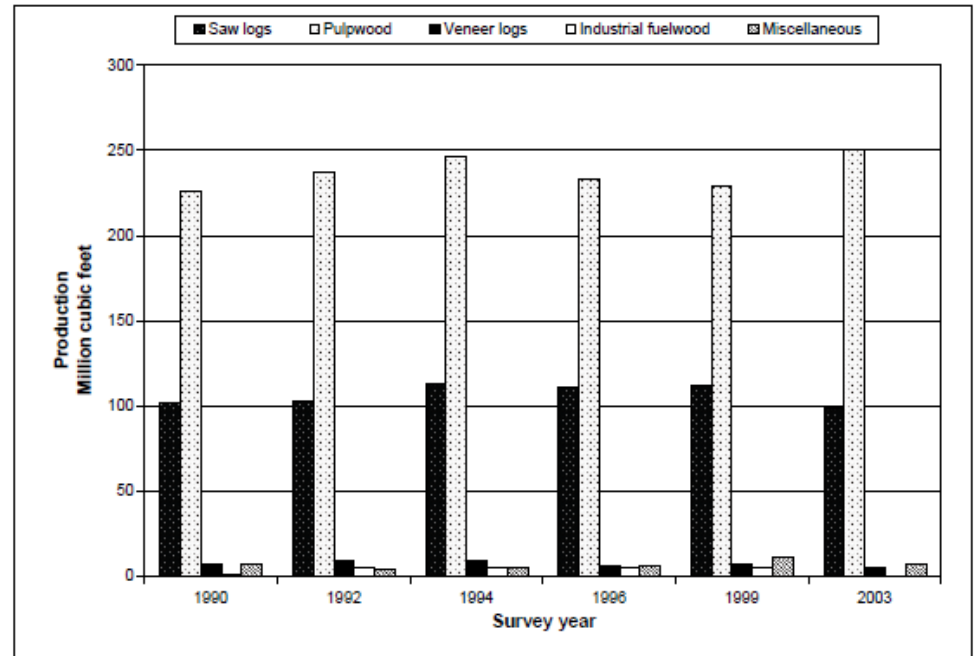
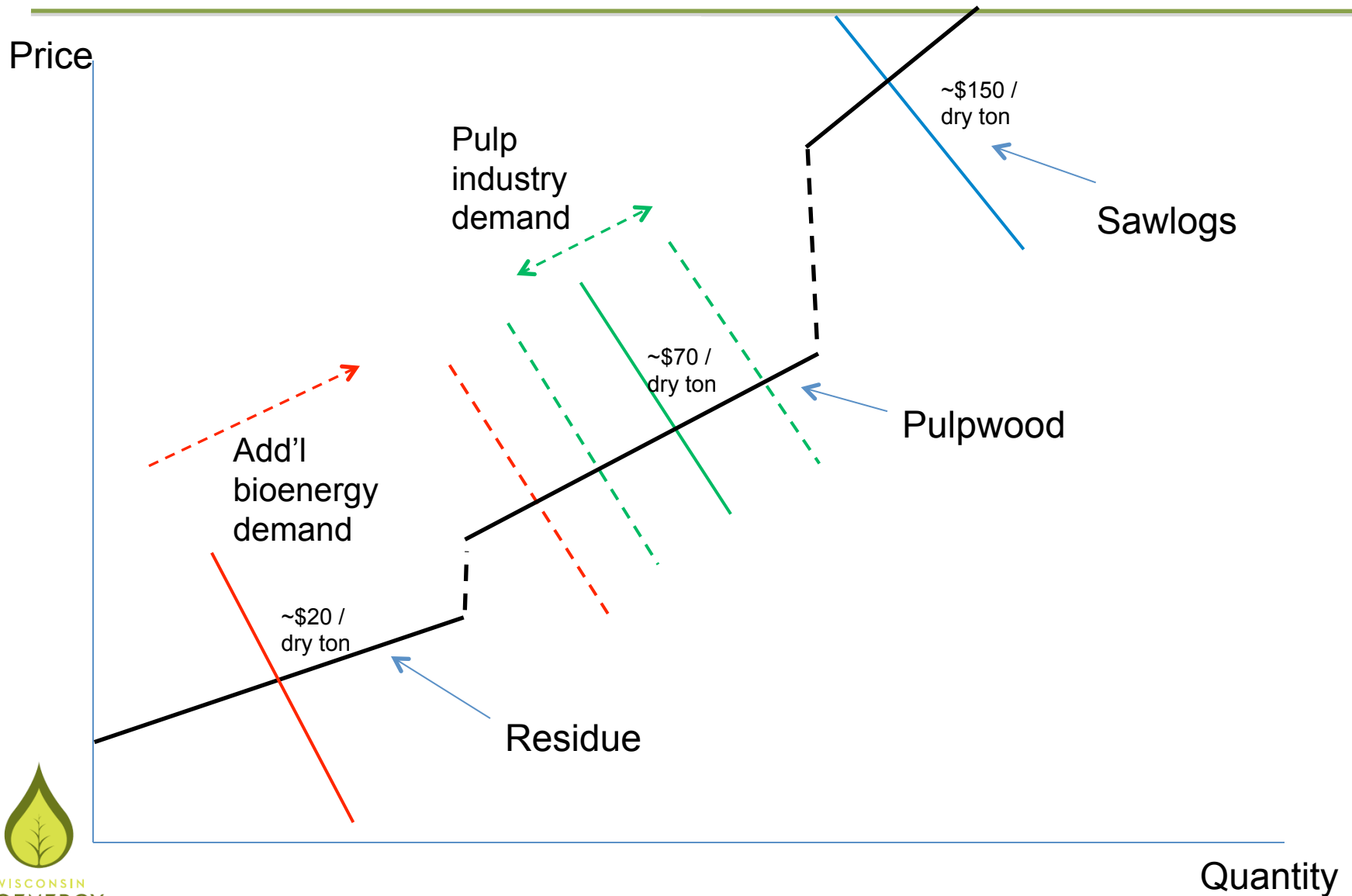


Figure 3.—Wisconsin industrial roundwood production by roundwood category and year.

Roundwood (MCF)	Sawlogs	Pulpwood
360.8	98.2 (27%)	250.8 (70%)

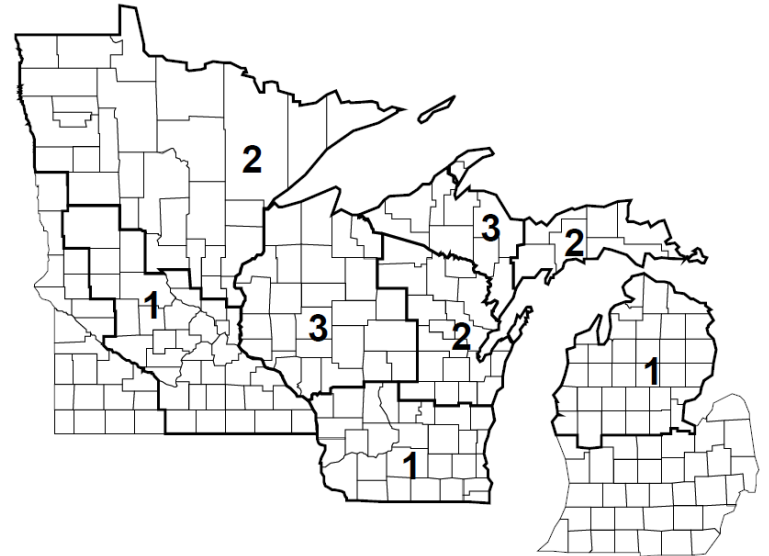


Forest Products – Supply/Demand

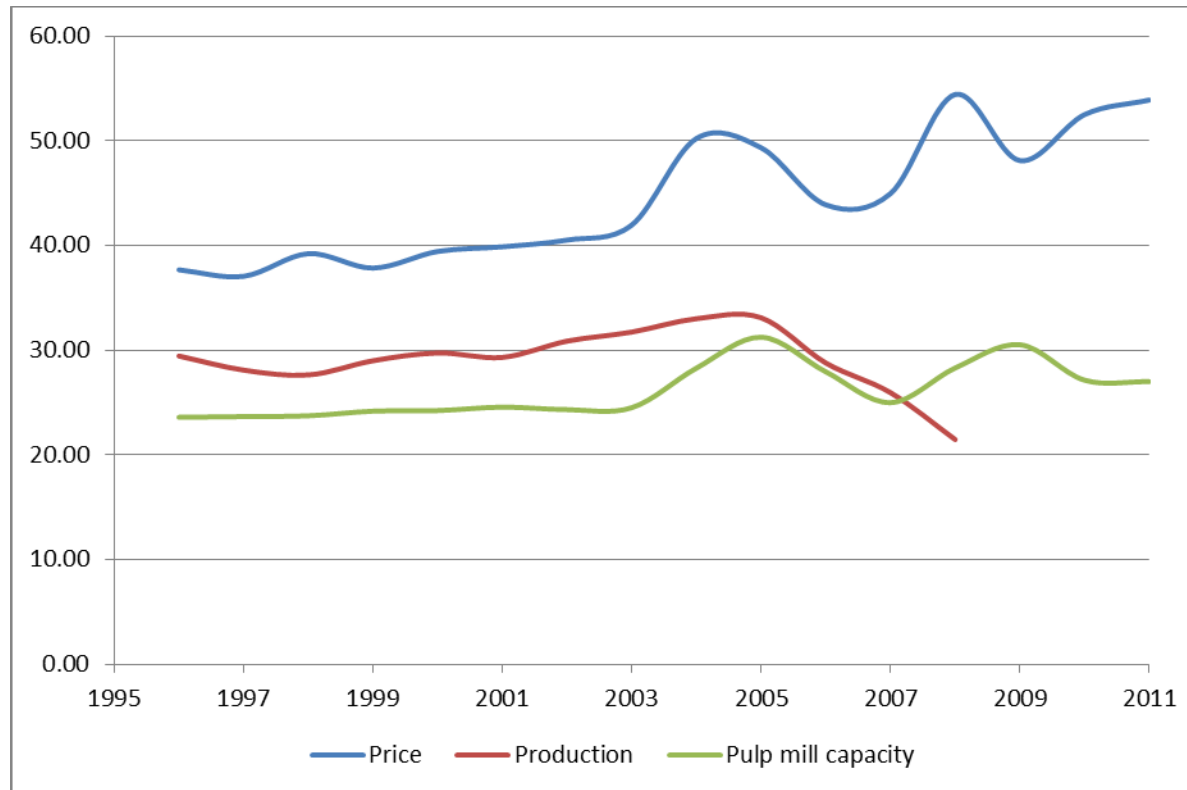


Data

- State and 3 regions
 - region 1: South; region 2: NE; region 3: NW
- Pulpwood
 - Annual production and price data over 1996-2008
 - Quantity: Northern Research Station, NFS
 - Price: Timber Mart North© Price Report
 - Demand : Pulp mill capacity (Lockwood Post Annual Directory)



Pulpwood Production, Delivered Price and Pulp Mill Capacity (Normalized) in WI (1996-2011)



Price: 1996-2011 (\$/ton)

Production: 1996-2008 (cords; /100,000)

Capacity: 1996-2011 (tons/yr; /300)

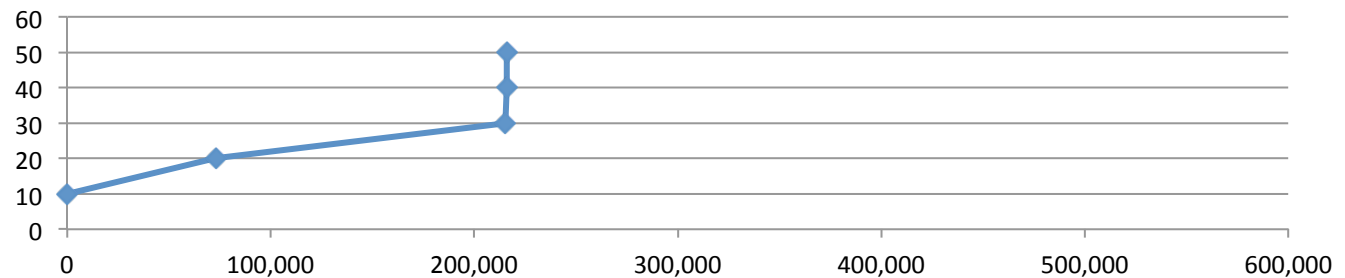


Wood Residuals Supply/Demand Analysis

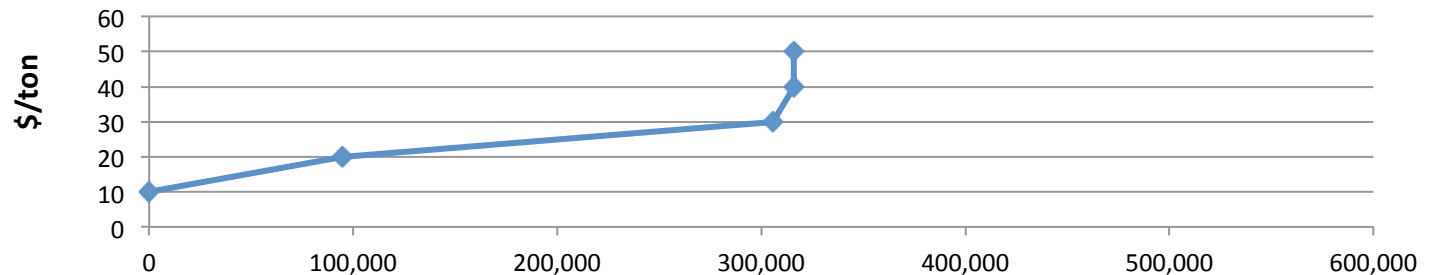
- Data from Billion Ton Study

- Vertical part of curve indicates limit of supply

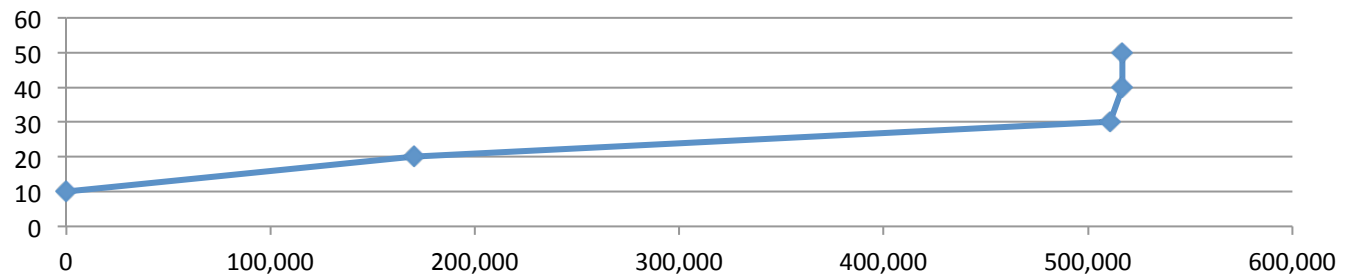
Region 1 (S)



Region 2 (NE)



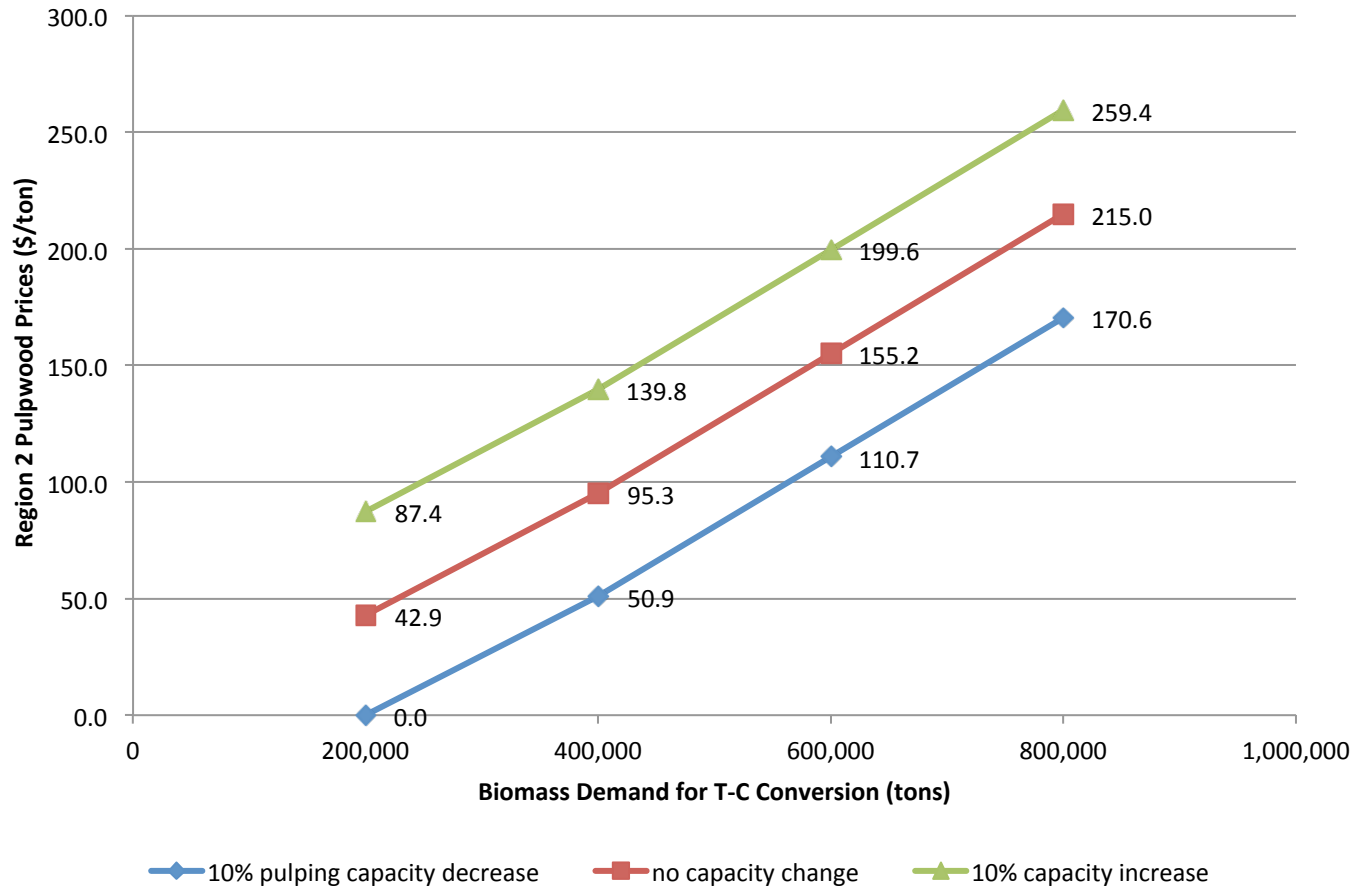
Region 3 (NW)



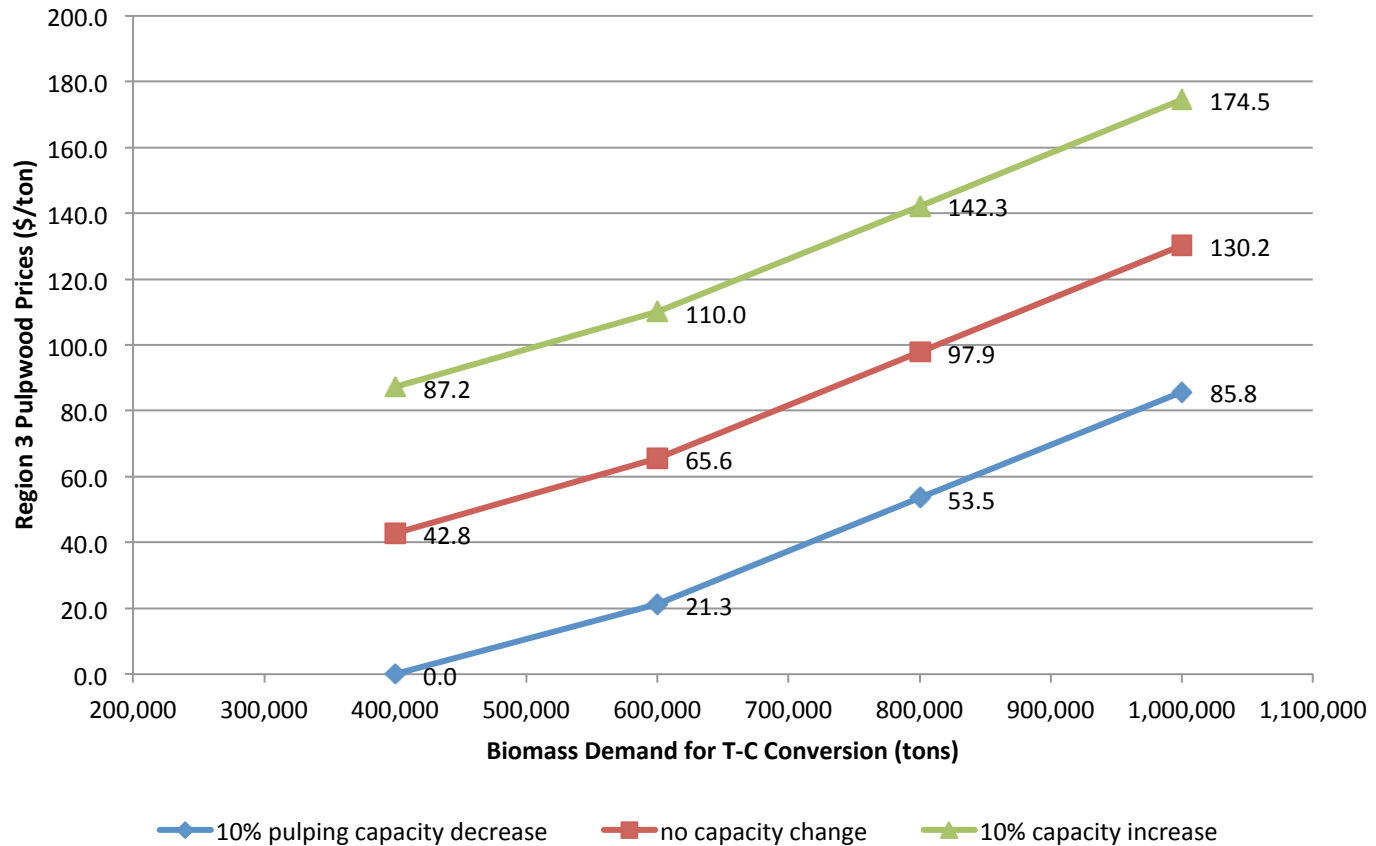
tons



Impact on NE Region Pulpwood Market



Impact on NW Region Pulpwood Market



◆ 10% pulping capacity decrease ■ no capacity change ▲ 10% capacity increase



Conclusions

- Wisconsin has a large amount of biomass available for bioenergy projects
- Pockets of high density biomass create opportunities for aggregation
- Woody biomass is only source tested to consistently have quality needed for thermal conversion
- With a developed forest products industry only wood residuals can be used without impacting regional wood prices
 - NW region of WI - 2 plants at 200,000 ton/year each
 - NE region of WI - 1 plants at 200,000 ton/year each



Opportunities

- Other opportunities for thermal biomass
- Southern region – small thermal/larger aggregation areas
- Enhance quality of herbaceous material
 - Improved harvesting
 - Leaching technologies
- Use Short Rotation Woody crops
- Increase productivity of WI forest
 - 16.3 million acres
 - Produce > 0.4 ton/acre/year



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